far into the Mexican table land, and westward into Arizona; but, clearly, the area of its greatest abundance is the north and south strip of Texas known as the Black and Grand prairies. This strip of country includes the cities of Fort Worth, Dallas, Waco, Austin and San Antonio—in fact all of the large cities of the state except Houston and Galveston; and is preeminently the best part from an agricultural standpoint. Within this area, where conditions are at all favorable, the *Phrynosoma* population averages at least thirty to the acre. This is despite the fact that for a number of years these lizards have been captured and sold to visitors from the east.

The life history has not been well worked out, but the newly hatched young begin to appear by the first of August; so that it is safe to say that the ordinary agricultural operations such as spring and fall plowing, do not interfere with the life cycle. The natural enemies are few and unimportant, being mainly road runners and opossums.

The stomachs examined included the following forms: four species of ants; four species of weevils (very few boll weevils); four species of bees (mainly miner bees); eight species of beetles; three species of stink bugs; nymphs of grasshoppers and allied Orthoptera; five species of flies; and a few caterpillars, some of which have not yet been identified. The noxious forms found overwhelmingly outnumbered the useful forms.

Agricultural ants were found in 80 per cent. and stink bugs in 60 per cent. of the stomachs. Neither of these is much subject to the attacks of birds. Obviously this enhances the value of *Phrynosoma*. Incidentally, there was a remarkable consistency or homogeneity in the contents of the individual stomachs. For example, in one case, nearly all of the forms present would be Hymenoptera; in another, nearly all would be Heteroptera, etc. This could mean that individuals acquire a taste for sour food, or fatty food, etc.; or, what is more likely, that the same individual requires from time to time certain special elements in its food.

From the data thus far assembled, it can be safely affirmed that the horned lizards of Texas are of tremendous importance to agriculture in that region; and may, perhaps, play as important a part there as does the common toad in the better watered regions of the United States.

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SECTION D—MECHANICAL SCIENCE AND ENGINEERING. II

The Highways of Hawaii: H. K. Bishop.

Before the days of county government, the central government of Honolulu, under the superintendent of public works, improved many highways with first-class water-bound macadam, in many instances with a telford base. Under the county form of government, the county took charge of the maintenance of the roads already built and the construction of all new ones. It is needless to say that this system has proven unsatisfactory and unproductive of good results in general.

In 1910 and 1911, by legislative action, provision was made by the territory, to raise funds by means of a bond issue and to put the work of road improvement under this issue in the hands of a commission, to be known as the Loan Fund Commission. The writer was engaged in September, 1911, by the Hawaii Loan Fund Commission to prepare plans and specifications and to superintend the construction of the belt road improvement on the Island of Hawaii. The belt road, which is the main highway of the island, approximately parallels the coast line at a greater or less distance entirely around the island, a distance of approximately 250 miles.

In the work of improvement on Hawaii, the general plan adopted was to use water-bound macadam with a telford base in the wet sections, and bituminous macadam in the dry sections. It was also planned to give the water-bound macadam a surface application of bituminous material when the macadam had become sufficiently compacted to make such a treatment successful.

The greatest need of Hawaii is some form of territorial aid to the counties similar to that adopted by the majority of the states of the Union. Hawaii is also in need of some form of centrally controlled highway department which will insure the standardization of road work and a

continuity of the policy. The territory is going through practically the same experience that every state in the Union has been through in its road work.

Service Tests on Various Classes of Pavements: H. W. DURHAM.

A solid unyielding foundation is a necessity for all road construction, but type and details are purely a local question. Much unnecessary confusion is caused in road discussion by inability to discriminate between cause and effect and by laying more importance on details of specifications than on the result they obtain.

The only true test is that of service under conditions of actual use. Final selection must be made among a limited number of types and suit a limited number of conditions. Carrying intermediate operations in the problem of selecting road types to extremes of refinement is unnecessary in that the conditions to be satisfied are few, and the final selection must be from among these classes.

Service Tests of Stone Block Pavements in Brooklyn: H. H. SCHMIDT.

About five years ago studies were begun of the various granite pavements in the borough of Brooklyn, with a view to determining, if possible, the causes which created the objectionable features. Observation showed that certain granite blocks polished under traffic, so that they became extremely slippery; some wore down rapidly at the edges, causing the top of the block to become turtle-backed, which made the pavement extremely rough; some blocks were found which disintegrated under traffic, and still others were extremely rough and not well-shaped, owing to the fact that they were made from a granite which had improper cleavage planes. We learned from the service tests of the stones actually subjected to traffic, that the mineralogical composition of the granite, the presence or absence of certain minerals, and the proportions in which they occur, as well as the size of the crystals, all had a direct bearing on its value for paving purposes.

After a conclusion had been reached as to the most desirable granite, a study of the size, dressing and filler was taken up. With the use of a concrete base, the extreme depth of the block was unnecessary, and the depth was therefore reduced from eight to five inches. With modern granite block it is possible to obtain joints averaging from a quarter to three eighths of an inch. The blocks are laid so close together that a considerable area of the blocks touch one another, thus giving stability to the pavement, even without the joint filler. It is unnecessary with the modern granite block pavement to use paving gravel, and the modern practise favors the use of a mixture of tar or asphalt with hot sand, poured into the joints.

Wood Block Pavements: W. P. TAYLOR.

The Value of the Absorption Test on Wood Blocks: GEORGE W. TILLSON.

When municipal engineers were considering the advisability of laying treated wood block pavements some twelve or fourteen years ago, it was uncertain as to just what should be the requirements of the specifications. It was felt that it was necessary to prevent the blocks from decay and also to treat them so that they would be stable under all climatic conditions; that is, they should not absorb so much water as to swell and cause the pavement to bulge, during a wet spell, nor should they shrink too much in dry, hot weather, so that they would become loose.

After careful consideration, it was decided to require an absorption test of the blocks. The test provided that after being dried in a kiln at a temperature of 100° F. for 24 hours, the blocks should not gain in weight more than 3 per cent. during immersion. Pavements were laid under this specification in 1903 and 1904, and on one street with a preservative that did not contain any resin, but was a specially prepared oil. The blocks obtained did, however, conform to the requirements as to weight and absorption. These pavements have been in use 10 and 11 years, without any expansion joint, and have required almost no attention on account of the instability of the blocks. In certain cases where pavements were laid not under the supervision of the city, so that the absorption test was not applied, the pavements did expand to a very considerable extent.

The city of New York is the only municipality of which the writer knows where the absorption test is required, and it is also the only city, in his knowledge, where an expansion joint is not used. The writer firmly believes that with a heavy oil treatment of 20 pounds and a specification requiring an absorption test, as given above, satisfactory results can be obtained without an expansion joint.

Sand Cushion vs. Mortar Bed for Wood Block Pavements: THEODOR S. OXHOLM.

In this country it has been the custom for many years to lay wood block pavement on a concrete base with a cushion of sand or a bed of mortar between the base and the blocks. A sand cushion is intended primarily to smooth out the

roughness and inequalities in the concrete, so that the blocks might rest evenly thereon. Secondly, the yielding surface of the sand permits the roller to press the blocks into it until they present a smooth surface, adjusting the slight inequalities in the depth of the blocks, and thirdly, the sand has a slight resiliency and protects the blocks somewhat from surface wear. The mortar bed performs the same office as the sand as an equalizer of the concrete surface and the surface of the finished pavement, but there the similarity ceases, for, as the mortar gradually sets it forms a hard unyielding bed for the blocks to rest upon, sacrificing resiliency for immobility.

There are two objections in the writer's opinion to the use of a sand cushion. First, when cuts are made for any purpose through the pavement, it frequently happens that weeks and months elapse before repairs are made; during this time, storm water works its way between the blocks and base and disturbs considerable quantities of pavement that will have to be relaid. This is especially noticeable on streets with a considerable grade, and could not occur with a well-set mortar bed. Second, it would seem that even the slight resiliency of the sand cushion would mean the unstable condition of each block with respect to its neighbors, and a consequent lack of support on sides and ends which is of the utmost importance. The one objection to a mortar bed has always been that the mortar has been mixed damp and time must be allowed for it to set hard (three or four days), before traffic could be admitted, whereas wood block pavement on sand cushion can be thrown open for traffic as soon as completed. The writer has overcome this objection by mixing the mortar dry, and allowing it to set as moisture reaches it through the joints which are always of sand. The roller and immediate traffic work the blocks down to their final beds before the mortar sets. Work of this kind has been examined at plumbing cuts and it has been found that the mortar was set up hard, though traffic had been allowed on the new pavement as soon as completed, and the surface was still uniform.

Cement Concrete Pavements: Percy H. Wilson.

The author states that the basic principle of the modern concrete road goes back to the ancient Roman roads in that the latter involved the use of puzzolana, the cement used by the Romans, while Portland cement is used as a binder in the modern concrete road.

The author emphasizes the following as conspicuous advantages of the concrete road:

Absence of mud and dust.

Roads passable at all seasons.

An even but gritty surface texture which prevents horses and cars from slipping.

A flat crown making every foot of road surface available for traffic.

Extreme durability increasing with age and exposure to the elements.

Imperviousness to frost and heat.

Moderate first cost and minimum maintenance cost.

With the establishment of expansion joints at proper intervals the cracking of concrete road had been practically eliminated, but when cracks do occur they are filled with tar and sand at small expense, this treatment, to all practical purposes and intents, restoring the slab to its monolithic character.

The paper describes structural methods and calls special attention to the importance of using only the best quality of materials, strict observance of specifications and careful workmanship.

Cement Concrete Pavements with Thin Bituminous Surfaces: W. H. Luster.

The concrete surface standing exposed to the weather and chance traffic for fourteen days becomes dirty, and before the hot bitumen was applied it was thoroughly cleaned in order to bond the two materials. Cleaning is of the utmost importance, and to that end the concrete was swept first with wire brooms, then with ordinary house brooms and then flushed with water under pressure by means of fire hose, and while the water was flowing was swept in the direction of the flow to the drainage inlets, but even then there remained the cement scum, or laitance, which always forms at the low spots to which it drains, and there hardens; this must be removed, for it is always smooth and no bitumen will adhere to it, and even if it did, it is not a suitable material for road metal, as it is soft and brittle and soon disintegrates under traffic.

The refined tar was applied hot by spraying under pressure from a moving auto truck tank, containing about one thousand gallons. A comparison of area covered with the capacity of the tank showed that the quantity spread was about one gallon to every three square yards. The bitumen was then covered with a coating of fine quartz gravel, the largest size grain being three eighths of an inch in diameter, and spread in the proportion of one cubic yard to one hundred square yards of surface. The street as thus pre-

pared was closed for twenty-four hours, after which traffic was admitted.

This thin bituminous coating acts in four capacities: First, it waterproofs the surface; second, it acts as a carpet and deadens the noise of traffic; third, it affords good foothold for horses, and fourth, it prevents abrasion of the concrete, thus prolonging its life.

Topeka Bituminous Concrete Pavements Constructed with Tar Cement: PHILIP P. SHARPLES.

The Topeka bituminous concrete is shown to be a revival of types of pavements laid with coal-tar cement twenty-five years or more ago.

The vulcanite pavements of Pittsburgh and tar concrete pavements of New England are described and compared with Topeka specifications.

The precautions necessary to secure successful work with the Topeka specification using coal tar cement are given.

Bituminous Pavements with Two or More Layers of Bituminous Concrete: ARTHUR H. BLANCHARD.

In cases where one product of a stone-crushing plant is used for the aggregate of the wearing course of a bituminous concrete pavement and this product is composed of broken stone varying but little in size, let us say from $\frac{3}{4}$ in. to $1\frac{1}{4}$ in., it will be advisable to use two layers of bituminous concrete. If the above product was used for the first layer and was constructed with a compacted thickness of from $1\frac{3}{4}$ to 2 inches, the second layer might properly be composed of broken stone from $\frac{1}{8}$ to $\frac{1}{2}$ in. in size and spread about $\frac{1}{2}$ in. to $\frac{3}{4}$ in. in thickness. After the second layer had been rolled the pavement could be finished with or without a seal coat of bituminous cement and a dressing of uncoated stone chips. This method is suggested in order to secure with the above type of broken-stone product a surface of the wearing course which will be as dense as when a product ranging in size from $\frac{1}{8}$ inch to $1\frac{1}{4}$ inch is used and the pavement finished with a seal coat of bituminous cement and stone chips.

From a historical standpoint it is of value to note that an English bituminous pavement of similar type was described in the *Engineering Record* of July 23, 1898. The fundamental principles involved have been made use of in the many successful bituminous concrete pavements constructed in England during the past fifteen years under the trade names of Tarmac and Quarrite.

Bituminous Macadam Pavements (Penetration Method): FREDERICK STEELE STRONG.

In determining the quantity per square yard of bituminous material to be used in construction of a bituminous macadam pavement there are four paramount functions to be considered: First, the nature and consistency of the bituminous material; second, the quality of the stone; third, the depth and sizes of the course; fourth, the kind of traffic and severity of climatic conditions.

With this data, the following equation has been deduced for the proper amount of binder to be used in cases where the stone is of low crushing and abrasive strength, this classification not to include any stone which is so poor as to be questionable or worthless. Let Y represent the number of gallons to be used per square yard. Let X represent the depth of the top course in inches. Then $Y = 9/10\ X$. For instance, with stone of low test, and depth of stone of 2 in., we determine that the quantity of binder should be approximately 1.8 gals. per square yard; and by using this equation again, it is found that for a depth of 3 in. the amount of bituminous material should be 2.7 gallons per square yard.

This binder is to be applied in two applications, the first to be two thirds the full amount and the second the balance, and the application is made by pressure machine. I believe no top course for a road of this type should be less than 3 in. in depth. The best stone available should be used even if its cost would entail the use of cheaper material in bottom course, but by this I do not depreciate the importance of a foundation, as without this any road is worthless.

Some Ways to Differentiate between Bitumens: GEORGE P. HEMSTREET.

The Present Status of Adhesive and Cohesive Tests of Bituminous Materials: JOHN S. CRANDELL.

During the past year the writer has made a series of tests to determine the binding values of a number of bituminous binders. The first tests were made as follows: Cylindrical briquets 25 mm. high $\times$ 25 mm. diameter, composed of stone, sand, filler and binder were molded under a pressure of 500 kilos per square inch, or 750 kilos per square inch, and were then allowed to season. They were then tested in the small Page Impact Machine that is used for the cementation test of stone. The number of blows required to break or crush each briquet was recorded. Different percentages of the ingredients were tried. It was found that pieces of crushed stone were cracked while in the molding machine. Other mechanical

difficulties developed, and it was decided to increase the size of the briquets to 35 mm. high × 50 mm. diameter. No difficulty is now found in molding the specimens.

These tests, which the writer has called binding value tests, furnish (*a*) an easy means of comparing the adhesive and the cohesive strength of binders, (*b*) a control of the amount of binder to use, and (*c*) a quick way of determining the correct amounts of stone, sand and filler to use.

The Purchase of Asphalt and Asphaltic Cement on the Bitumen Basis: W. H. Broadhurst.

To those familiar with the nature and composition of asphalts and asphaltic cements, the advantages from an economic standpoint of purchasing these materials on the bitumen basis is obvious. The bitumen, or carbon-bisulphide-soluble content of an asphalt, being the cementitious material which binds the mineral aggregate of an asphalt pavement or bituminous concrete together in a compact mass, it follows that, without giving consideration to the character of the insoluble material, or whether the same improves the value of the asphalt as a paving material or is deleterious, the greater the percentage of the insoluble material, the less the efficiency of the asphalt in respect of the number of square yards of roadway per ton of asphalt a given asphalt or asphaltic cement will lay. Hence to place all asphalts in competition on an economically sound or even basis, the same should be bought on the basis of the contained bitumen. Specifications for the purchase of asphalt should therefore be drawn outlining the requirements, first as to quality, and secondly, as to quantity of contained bitumen, instead of requesting merely bids for refined asphalt, or asphaltic cement, which is a very prevalent custom to-day with many municipalities operating municipal asphalt repair plants and state highway commissions purchasing asphaltic cement for state roads.

A Change in the Asphalt Pavement Specification: John Martin.

Allowable Maximum Penetration of Various Types of Asphalts for Use in the Several Kinds of Bituminous Pavements: H. B. Pullar.

The writer would state that in his own opinion there is no set rule which can be adopted or followed in setting a maximum penetration for any type of asphalt or any type of bituminous construction; that it is necessary to consider the local conditions in conjunction with the various bituminous materials on the market and to incorporate them in such a way into the specifications so as to get most satisfactory results. The writer further believes that the maximum penetration is merely one of the many small but important details of construction which must be considered separately for each different piece of work, and that in order to get bids on bituminous materials specifications should be so drawn with limits sufficiently open to produce maximum competition with reverting specifications on bituminous materials, these reverting specifications to be drawn up with limits narrow enough to exclude anything but the highest quality of material for that particular type of bituminous material and at the same time not be unjust to the producers of the different kinds of bituminous materials. Under this kind of a specification it is possible to take into consideration all of the local conditions, the different characteristics, and the inherent qualities of the different bituminous materials and to incorporate in these specifications the allowable maximum penetration for the particular type of pavement and under the particular conditions it is to be constructed, and the writer believes that it is only by this method that the most successful results can be obtained.

A Review of the Use of Bituminous Materials in Highway Engineering during 1914: Arthur H. Blanchard.

During 1914 the following noteworthy developments have been noted:

In specifications for bituminous materials there has been a tendency to adopt a group of type specifications in place of a blanket specification. By this method engineers have been able to secure the most suitable grade of a given type of bituminous material for a given method of construction, as it is practicable to specify desirable limits for each type rather than have wide limits, as is necessary in blanket specifications. Another self-evident advantage is that more uniform material may be secured by this method.

Bituminous surfaces have been constructed (*a*) with more attention to the physical properties of the road metal composing the wearing course and the requisite dryness and cleanliness of the surface prior to application of the bituminous material; (*b*) using to a greater extent bituminous materials which do not require from several days to three weeks to set up; (*c*) generally employing pressure distributors in place of hand methods and gravity distributors.

In the construction of bituminous macadam pavements there has been a noteworthy tendency to (*a*) use bituminous cements of a lower penetra-

tion than formerly and (*b*) more thoroughly roll the wearing course prior to the first application of bituminous material.

Bituminous concrete pavements have increased in popularity in many sections of America. There has been a general tendency to use carefully heated aggregates and employ mechanical mixers. Bituminous materials of lower penetration than formerly are used in bituminous concrete, the aggregate of which is composed of one product of a stone-crushing plant, the sizes of stone ranging from ¼ in. to 1¼ in. The largest contract for this type of construction during 1914 was the Ashokan Highway, 37 miles in length, built by the board of water supply of New York City.

The third session was held on the morning of Thursday, December 31, Vice-president Dr. Frederick W. Taylor and Mr. O. P. Hood in the chair, with an attendance of about 70. The program of the session was as follows:

Vice-presidential Address: *Safety Engineering:* O. P. HOOD.

Engineering and Industrial Regulations for Promoting Safety in Industrial Establishments: JOHN PRICE JACKSON.

Recent Developments in Precise Leveling: WILLIAM BOWIE.

There should be in each city and state and throughout the whole country connected systems of leveling to form the basis and give the datum for the ordinary spirit or wye leveling.

The nation has, at present, about 31,000 miles of precise leveling with more than 13,000 substantial bench marks. The elevations in the precise level net are referred to mean sea level. The mean surface of the water at the starting points was derived from long series of tidal observations. Mean sea level is the natural and the best datum for a level net. In the first place, it is a fundamental datum, for it can be reproduced; again, with it, leveling can be started at many places with certainty that when the different lines are joined the agreements will be close. Also, leveling by different nations will agree when it is connected on the international frontiers.

There should be only one datum for the whole country, and this is only possible after the level net has been extended to such an extent that no place is far from a precise level bench mark.

The instrument used by the Coast and Geodetic Survey in its precise leveling is generally known as the "United States Coast and Geodetic Survey precise level." Its noteworthy features are that it is made of an alloy of nickel and iron which has a very low coefficient of expansion; its bubble is set down into the telescope near the axis of collimation; and its binocular system, by which the observer can see the bubble, cross wires and rod at the same time. The instrument was designed and made in the Coast and Geodetic Survey Office. It has proved very effective in enabling the observer to avoid or eliminate many of the errors which were in the leveling done with the older types of instruments.

All lines are run at least twice, in opposite directions. To be acceptable the two runnings of a section must agree within four millimeters times the square root of the distance in kilometers.

The average progress in the work per month is now about 86 miles for each party. The maximum progress ever made by one party was in October, 1914, when 148.3 miles were completed. The rapidity with which leveling is now done is due mainly to the use of the motor velocipede cars as the means of transporting the members of the party and to the more efficient organization and management of the leveling parties.

The great accuracy of the leveling is indicated by the probable error of the elevation at St. Paul, Minnesota (the least accurately known place in the net) resulting from the 1912 general adjustment of the level net of the whole United States, which is only $\pm$ 0.065 meter ($\pm$ 0.21 foot). The average correction to the lines forming the net for loop closure is about 0.15 millimeter per kilometer. An investigation of the small systematic and accidental errors in the precise leveling indicates that, when the ground is sloping, more accurate results are obtained on a cloudy afternoon, with a moderate wind blowing, than under the reverse conditions. When the ground is nearly level, the time of the day and the atmospheric and weather conditions do not seem to have any material systematic effect on the line of levels.

The Engineer Out in the World: MARTIN SCHREIBER.

The Teaching of Industrial Economics and Management to Engineering Students: HUGO DIEMER.

Recent engineering curricula show that instruction in industrial economics and management is being introduced in an increasing number of institutions. Examples are cited from the curricula of a number of well-known universities and colleges. Statistics regarding the positions held by the membership of the leading national engineering societies show that more than half of the com-

bined membership of these societies consists of men engaged as executives in manufacturing or contracting work. In such work ability as an inventor is less essential than familiarity with principles and applied methods of industrial management.

The speaker outlines the course in industrial engineering given at the Pennsylvania State College.

This course contains all the fundamental mathematics, underlying science and mechanics given in the standard engineering courses, but in place of the more technical work in designing and testing we introduce work in organization, management, theory of accounts, factory accounting, foundry and pattern-shop methods and organization, machine-shop methods and organization, factory lay-out and design and application of such methods of scientific management as planning departments, including orders of work, bulletining, making of time studies, preparation of introduction cards and tool lists, keeping of cost records and accounts on commercial work actually sold, on the one hand, and certain essential exercise work, on the other hand. The degree obtained by students graduating in this course is that of Bachelor of Science in Industrial Engineering.

Methods and New Apparatus for Measuring the Electrical Conductivity above 1500° C. of Vapors at Normal Pressures: Edwin F. Northrup.

The electrical conduction of gases and vapors at atmospheric pressure at temperatures above 1200° C. have apparently been little investigated quantitatively. If the investigation is to extend to metallic vapors means must be provided for producing and measuring very high temperatures, and if high pressure can be combined with high temperature, a searching experimental method will be provided of ascertaining the true nature of metallic conduction. Some progress is reported in providing the necessary outfit for the investigation of gaseous and vapor conduction at atmospheric pressure and at temperatures up to the melting point of platinum.

A furnace is described which gives safely a temperature above the melting point of platinum and which will maintain a temperature above the melting point of nickel for at least 140 hours. The furnace can then have its life renewed by the introduction of a new heater-unit. A container for the hot gases or metallic vapors is described.

It is shown that the conduction is considerable but complicated in character. It depends (1) upon the form of the container, (2) probably, upon the material of the container, (3) upon the applied voltage, (4) upon the direction of the applied voltage, (5) upon the temperature, (6) upon the frequency, when an alternating voltage is employed and (7) upon the nature of the gas or vapor.

A description is given of a series of measurements. The data obtained is given, partly in a table and in ten curves.

The considerable conductivity exhibited by a mixture of CO and N above a temperature of 1500° C. suggests the idea that the conductivity found for refractory oxides at and above this temperature is due in considerable part to the hot gases which fill the interstices of the material. This idea was put to the test of experiment and it was found that, under identical conditions in respect to method of measurement, cross section and length of material, etc., at the temperature of 1530° C. through pure aluminum oxide 36 milliampères and through a mixture of CO + N 8.5 milliampères passed, the pressure being 50 volts. Hence it is concluded that approximately 24 per cent. of the conductivity of pure aluminum oxide at this temperature is due to the conductivity of the gases in its pores. It therefore seems safe to make the general statement; *that when the temperature exceeds 1500° C., it is impossible to obtain even approximately good insulation by any means.*

One of the most interesting properties of the conducting power of a very hot gas is the asymmetry of the conduction. In a particular case, at a pressure of 80 volts, 15.5 milliampères passed from a tungsten wire, axially located, to the walls of a graphite cylinder when this wire was made negative, and 45 milliampères when this wire was made positive. The temperature in both cases being 1510° C.

The writer states that high-temperature investigation presents innumerable problems, and it is in his judgment the most fruitful field for chemical and physical inquiry which is at this time presented to chemists and physicists.

Saturated Vapor Refrigerating Cycles: J. E. Siebel.

The author analyzes the energy conversion in refrigerating cycles conceived to be operated perfectly reversible by a saturated vapor with negative specific heat (steam as a representative).

Accordingly, it is found that the work required to produce a certain amount of refrigeration in

such a cycle is greater than in a refrigerating cycle operated reversibly by dry vapor of the same medium.

In the latter case the relation between the work W and the produced refrigeration Q is expressible by the equation

$$W = \frac{Q(t - t_0)}{T},$$

while in the former it must be expressed by the formula

$$W = \frac{(Q + Q_1)\ (t - t_0)}{T},$$

Q_1 representing the amount of heat which is to be withdrawn in the compression stage to keep the vapor saturated in a cycle operated between the temperatures t_0 and t, T representing the temperature t in absolute degrees.

The Moment of Inertia in Engineering: D. J. MCADAM.

1. Moment of inertia is so important in engineering that its mechanical meaning ought to be well understood and clearly defined.

2. Standard works on mechanics for engineers and mechanics of engineering show that they lose sight of the mechanical effect which it represents and define it and use it as "a name given to a quantity much used by engineers"; and some engineers ridicule radius of gyration as "not being a radius and having nothing to do with gyration."

3. The source of the difficulty in the minds of the users of moment of inertia is: (*a*) Dread of calling inertia a force. (*b*) Failure to see that one of the factors in the square of the arm in the moment is a reducing factor.

4. The ordinary definition of moment of inertia is a secondary statement. It is simply a statement of the result of an algebraic multiplication in form of an algebraic formula; or it is a statement of the method of getting that algebraic formula.

5. The true definition of moment of inertia must define it as the moment of forces just as truly as any other moment of forces. And it must state the unit of force or acceleration in which the forces are expressed.

6. *Definitions.*—(*a*) The moment of inertia of a *particle* with reference to a point is the moment of the force, which acting upon the particle constantly at right angles to the line joining the particle to the point and acting constantly in the same plane, will produce radian acceleration.

(*b*) The moment of inertia of a *beam* at a section is the sum of the moments of the forces which are acting on the various elements of the section when the outer elements are stressed, so that there is unit stress at unit distance from the neutral axis.

7. It is to be observed that in (*a*) the unit force is one producing unit acceleration, and in (*b*) the unit force is unit intensity at unit's distance from the neutral axis. Both are forces, however, expressed in terms of a unit force.

8. In the expression for the moment of inertia of a mass about an axis parallel to the axis through its center of gravity, the term to be added to the moment of inertia of the body about the axis through its center of gravity is the moment of the force which will have to be applied to the mass at its center of gravity to cause it to have radian acceleration. This we find to be $FR = MR^2$.

The Use of Electricity in the Manufacture of Portland Cement: MALCOLM MCLAREN.

Motors were first used in cement manufacture for driving light machinery in the outlying portions of the mill. As the mills increased in size the use of motors became more general, until now in many cases the entire mill is operated by electric power.

A method is given for determining whether, in an existing mill using steam engines for driving the machinery, it would be advisable to adopt electric drive. It is shown that the mill output should be increased by the change, but that the greatest saving in operating costs would be due to the fact that the steam economy of the steam turbines used with electric drive should be much greater than that of the engines they would replace.

Considering the question of whether the cement company should generate its power or purchase this from a supply company, it is shown that the cost of power per unit depends largely on the amount of power developed. A large supply system, therefore, which carries the combined load of many customers, should be able to produce power at a lower rate than could be done by any of the smaller constituent companies.

Various Engineering Problems in Connection with the Hydro-Electric Plant of the Housatonic Power Company at Bulls Bridge, Connecticut: CHARLES RUFUS HARTE.

Latest Developments in Marine Electrical Engineering: H. A. HORNOR.

This paper gives a brief review of progress in the development of marine electrical installations. It emphasizes the importance of electric steering, anchor windlass and other recent requirements. The possibilities of under-water communication are considered and improvements in searchlight projectors recorded. The essential points in connection with the introduction of electric propulsion and the opening field of possibilities not only in the design of efficient electrical apparatus but also in the effect upon the art of naval architecture are concisely stated.

The Nolachuckey Hydro-Electric Plant of the Tennessee Eastern Electric Company: W. V. N. Powelson.

The Location and Maintenance of Railroads and Highways along Steep Slopes: Walter Loring Webb.

The paper describes the development of a new principle of construction, when it is necessary to place the roadbed of a railroad or a highway along a slope which already is so steep that any increase in the rate of the slope, made by forming the side slopes above or below the roadbed, causes frequent slides. The usual practise has been to construct retaining walls on the upper or the lower side of the roadbed (or perhaps on both sides) which are necessarily expensive, since they must always sustain a great weight of earth. The method described utilizes the skeleton construction permissible by reinforced concrete and reduces to a minimum the stresses which must be sustained by the structure. An illustrated example of the application of this principle, as developed by the writer in Oil City, Pa., is given in detail. Another illustration of the same fundamental principle, as recently described in the technical press, is also given.

Construction of the New Double Track Tunnel of the B. & O. R. R. through Alleghany Mountains at Sand Patch, Pennsylvania: Paul Didier.

Reconstruction of Bridge No. 100, Pittsburgh Division: J. C. Bland and John Miller.

This bridge, situated a little west of Coshocton, O., was partially destroyed by flood in March, 1913, and the wrecked spans temporarily replaced by girder spans.

The structure, before the flood, consisted of four double tracks through pin-connected truss spans, each 152 ft. 2 in. c. to c. end pins, and was replaced by three double track, through riveted truss spans, each 240 ft. c. to c. end pins. The total shipped weight of the three spans was 2,740 tons.

The old masonry was replaced by new concrete piers and abutments, the foundations for these being sunk by pneumatic caissons. This new masonry was built by the Foundation Co., of New York.

The new bridge was erected on falsework on the downstream side of the old, and when completed, was used as a run-around to carry traffic while the old structure was being dismantled. The new spans were then rolled into position.

Both the weight moved, 3,250 tons, and the distance moved through, 44 ft. 9 in., constitute a record for an operation of this nature.

The new steelwork was manufactured by the American Bridge Co., of New York, and was erected by the Seaboard Construction Co.

The bridge was designed by Mr. J. C. Bland, engineer of bridges, Penna. Lines West of Pittsburgh, under whose supervision the erection also was carried out.

A Balanced Cantilever Bridge: Henry H. Quimby.

A bridge of a new type was recently constructed at Chester, Pa. It consists of two independently acting parts, each being a double cantilever of ten longitudinal ribs of reinforced concrete resting on a pier over which it is balanced with a counterweight, the channel ends of the cantilevers being connected by a short so-called suspended span, and the whole forming in appearance a concrete arch.

The type was devised as the most economical method of securing an ornamental arch bridge which was desired at this point by the public authorities for esthetic considerations, the subsurface conditions making a real arch very expensive. These conditions consisted of deep soft mud on one side of the river underlaid with a bed of rock sloping steeply away from the channel to a considerable distance and depth, affording no natural skewback for an arch to thrust against.

The pier on the deep mud side is on wooden pile foundations with concrete capping, lateral stability being obtained by surrounding the pier with spur or batter piles.

The bridge is one hundred and sixty feet long over all, with the main span ninety-five feet centers of piers, and the wings thirty-one and thirty-four feet, respectively. It is sixty feet wide, with cartway thirty-six feet between curbs.

The action of the double cantilever is that of the double overhanging gantry crane, the dead load balanced with equal moments over the middle

of each supporting pier, and the traveling live load shifting the center of combined load forth and back over the middle within a range not exceeding one third of the width of the pier, so that tension is never developed at the edge of the bearing.

An open joint was made at one end of the suspended span to provide for temperature movements as well as to keep the cantilevers independent of each other, but the pressure of the earth fill against the ends of the bridge keeps the joint in contact and makes the bridge a real arch to the extent of that pressure, and giving it, under ordinary loads, all the rigidity of an arch.

The Newark Terminal: MARTIN SCHREIBER.

Cooperation between the Physicist and the Engineer: CARL HERING.

Defining engineering as "applied physics," and stating that the province of the physicist is to discover and formulate the laws of nature, while that of the engineer is to then apply these laws and data to the construction of useful structures —the author urges a closer cooperation between them, and shows how much the work of the engineer is dependent upon that of the physicist.

As illustrations of its importance he cites cases in which engineering structures failed due to incomplete statements of the laws of nature in books on physics; or in which in applying the physicist's laws it was found by the engineer that they were faultily stated, resulting in misleading or even wrong results. In other cases the engineer discovered new laws which it was the province of the physicist to have given him, the physicist being better equipped and trained for such research than the engineer.

The physicist taught nothing at all in his books about any internal forces in conductors due to the electric currents flowing through them, yet the engineer in his constructive work found them to exist. Maxwell's famous law of induction, as stated by the physicist, when applied to a specific case gave results which were contrary to the facts, as was found in the constructive work of the engineer. Physics says nothing about axial electromagnetic forces in conductors, yet the engineer finds them to exist. The physicist's work is the foundation of the structure of the engineer, and with an insecure or doubtful foundation, the structure is not dependable. Much time, money and failure can be saved to the engineer if the physicist gives him all the necessary data and states the laws of nature correctly and completely.

Attention is called to cases in which quantitative laws of certain physical phenomenon have not yet been established by the physicist. Overlooking the distinction between the physical and chemical parts of thermo-chemical processes is criticized.

Concerning units for measuring physical quantities, it is shown that the physicist is far ahead of the engineer and the latter would often save himself much work in his calculations by adopting decimal multiples of the absolute units, as was done in the case of the electrical units in which all the conversion factors are made unity by definition. Useless double units should be eliminated, but for some cases double units are advocated for eliminating the factor π from many calculations. In creating new units, physicists are urged to base them on the absolute system, to avoid the use of conversion factors. The physicist's unit of "brightness" of light is criticized as a physical inconsistency and as being an unnecessary double unit.

Numerous references are given to articles in which the topics touched upon are discussed more in detail. The author hopes that his illustrations will show the importance and the benefits of a closer cooperation between the physicist and the engineer.

The fourth session was held on the afternoon of Thursday, December 31, Mr. O. P. Hood in the chair, with an attendance of about 35. The program of the session was as follows:

Some Engineering Achievements in Philadelphia and Environs: EDGAR MARBURG.

The Hydraulic Laboratory of the Civil Engineering Department, University of Pennsylvania—Its Equipment and Operation: WILLIAM EASBY, JR.

Some Laboratory Accessories for Materials Testing: H. C. BERRY.

Correct Methods of Creating and Maintaining Channels at the Mouths of Fluvial and Tidal Rivers, and at the Outlets of Inclosed Tidal Areas: ELMER CORTHELL.

The Engineers' Interest in Deep Waterways with Special Reference to Mississippi River and its Tributaries: HARRY E. WAGNER.

The Tide Water Outlet of the New York State Barge Canals: D. A. WATT.

This paper presents a brief sketch of the work now being constructed by the federal government at Troy, N. Y., in order to provide a connection between tide water in the Hudson River and the

extensive system of state canals, known as the barge canal, now nearing completion by the state of New York. These new canals will provide a modern waterway, not less than 12 feet in depth, between the seaport of New York and the Great Lakes, with a spur running northward along the Hudson Valley to Lake Champlain. The work is practically a reconstruction of the existing system of canals, which have a depth of only 6 feet, but which, nevertheless, constitute an influential factor upon the freight rates of a considerable portion of the United States.

The works which will form the outlet at Troy of this great system will consist of a lock with two tandem chambers, which together will have an effective horizontal area of more than twelve times the area of the present single locks, and the dam will have a length of nearly a quarter of a mile. In addition to these works, between 20 and 30 miles of river channel have to be deepened an average of 3 to 4 feet, so as to provide the channel depth of 12 feet.

The American Bridge Company School Work at Ambridge: J. E. BANKS.

Some Features of the Engineering Plant for the New Agricultural School near Farmingdale, New York: RALPH C. TAGGART.

The Human Nature Element of Engineering Construction with Particular Application to Tropical Situations: T. HOWARD BARNES.

The Dome of the Columbia University Library: O. W. NORCROSS.

The Inspection Department in Its Relation to the Management of Manufacturing Organizations: FRED. B. COREY.

In this paper the author calls attention to the disadvantages inherent in the usual plan of factory organization, in which the inspection department is under control of the works superintendent, and to the great advantages to be gained by placing this department under authority of an executive reporting directly to the general manager, or other officer in control of the factory output.

The executive head of the inspection department should be thoroughly familiar with general engineering practise and standards. He should be well informed in all shop methods, including foundry and machine-shop practise, and be thoroughly versed in the use of testing machines and gages. He should, if possible, be conversant with chemical laboratory methods and apparatus, so as to be able intelligently to direct that part of his organization. Moreover, he should be familiar with the uses of the factory products and the conditions under which it is to operate after it has passed beyond control of the factory. He must have absolute control of every inspector in the plant and be held responsible for the quality of material and workmanship of all that the plant produces.

The relations that should exist between the inspection department and the sales and engineering departments are quite fully outlined. The inspection department, if rightly conducted, acts for the mutual protection of the manufacturer and the customer and can be of great assistance to the sales department in various ways. At the same time it should maintain the closest possible relations to the engineering department and plans are outlined by which practical cooperation may be secured.

Detail methods of inspection must be suited to the special conditions of each case. It is obviously absurd to try to apply big-shop methods to a small shop, and the converse application, while far more usual, is no more logical. Such matters must, therefore, be subjects of careful investigation and study in each individual plant.

The Application of Science to Telephone Engineering: GEORGE S. MACOMBER.

Reinforced Concrete as an Emergency Repair for Iron Chimneys: A. L. PIERCE.

Mining Engineering Problems Incident to the Development of the South African Diamond Mines: GARDNER F. WILLIAMS.

Shaft Sinking in Excessively Hard Rock: WILLIAM YOUNG WESTERVELT.

The Refrigerating Plant at the Washington Market, New York City: CHARLES H. HIGGINS.

Removal of Henderson Point at the Portsmouth Navy Yard: O. W. NORCROSS.

New Machine for Ginning and Cleaning Cotton: GEORGE T. BURTON.

Spiral Wrappings with Special Reference to Flat Spiral Springs and Stresses in Steel: B. SPENCER GREENFIELD.

At the conclusion of the session an inspection of the new engineering laboratories of the University of Pennsylvania was made under the direction of Professors Edgar Marburg, William Easby, Jr. and H. C. Berry.

ARTHUR H. BLANCHARD,
Secretary